AN EFFICIENT UP-LINK LOAD REDUCTION MODEL BASED ON CLUSTERING IN VANETS

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ABSTRACT

Vehicular Ad Hoc Networks (VANETs) enable communication between vehicles to avoid the accident. Cluster is a technique in VANETs used to group vehicles. The aim of this thesis is to mitigate uplink load at Base-Stations (BSs) resulted from the following: first, increased number of vehicles in the urban city leads to an increase in the number of cluster head (CH) in the network while each CH required uplink channel from BS. Second, increased vehicles mobility makes the clusters unstable and try to reserve another uplink channel from the BS. Third, the handover problem in the cell edges makes the CHs try to reconnect with the BS. Fourth, duplicated information sent from CHs to the BSs at the intersections make the BSs loaded by unnecessary information. This study proposed an Efficient Up-link Load Reduction (EULR) model to mitigate the uplink load at BSs. EULR model consisted of three parts: the first part, two novel algorithms Smart CH Election (SCHE) and Hybrid Cluster-Head Election (HCHE) to increase cluster stability and reduce the number of CHs changes in the network by selecting the best vehicle as cluster head (CH) based on two dynamic thresholds. Second part, Intelligent Cluster-Head (ICH) method is proposed which aims to mitigate handover problem of a CHs at the cell edge of a neighbor's BSs by transferring uplink connection to the CH that has the highest RSS and hence reducing load at the BSs. Last part, Dynamic Multi-Agent (DMA) method is proposed to avoid duplicated information transmission from CHs at intersections to the BSs. The DMA method filtered the CHs information by sending only new information to the BS; therefore, this method helped to reduce the load at BSs. Performance of the EULR model is evaluated through simulation with real-time datasets. Overall, the EULR model reduces the number of CHs by 9.53%, increased CHs stability by 40.38%, achieved less packet loss by 26.81% and reduced the duplicated information at the intersection by 81% than the previous related works. Finally, the proposed methods have shown significant network performance results compared to previous related works as stated in this thesis.

ABSTRAK

Rangkaian Ad Hoc Kenderaan (VANET) membolehkan komunikasi antara kenderaan untuk mengelakkan kemalangan. Kluster adalah teknik dalam VANET yang digunakan untuk kenderaan kumpulan. Matlamat utama tesis ini adalah untuk mengurangkan beban pautan atas di stesen tapak (BSs) berikutan daripada perkara berikut: pertama, peningkatan bilangan kenderaan di bandar bandar menyebabkan peningkatan bilangan ketua kluster (CH) dalam rangkaian manakala setiap CH memerlukan saluran pautan atas dari BS. Kedua, kelajuan kenderaan yang semakin meningkat menjadikan kelompok kenderaan tidak stabil sehingga menyebabkannya cuba menggunakan saluran pautan atas lain dari BS. Ketiga, masalah penyerahan saluran penghantaran di tepi sel menjadikan CH cuba untuk menyambung semula dengan BS. Keempat, maklumat yang disalin yang dihantar dari CH ke BS di persimpangan meningkatkan jumlah beban maklumat yang tidak diperlukan di BS. Kajian ini telah mencadangkan model Pengurangan Beban Hubungkan Efisien (EULR) untuk mengurangkan beban pautan atas di BS. Model EULR terdiri daripada tiga bahagian: bahagian pertama, dua algoritma baharu iaitu *Smart CH Election* (SCHE) dan Pemilihan Hibrid-Ketua Kluster (HCHE) untuk meningkatkan kestabilan kluster dan mengurangkan bilangan perubahan CHs dalam rangkaian dengan memilih kenderaan terbaik sebagai CH berdasarkan dua nilai ambang yang dinamik. Bahagian kedua, kaedah *Intelligent Cluster-Head* (ICH) dicadangkan yang bertujuan untuk mengurangkan masalah penyerahan saluran penghantaran oleh CH yang berada pada pinggir sel jiran BS dengan memindahkan sambungan pautan atas kepada CH yang mempunyai RSS tertinggi dan dengan itu mengurangkan beban di BS. Bahagian terakhir, kaedah *Dynamic Multi-Agent* (DMA) dicadangkan untuk mengelakkan penghantaran maklumat pendua oleh CH yang berhenti di persimpangan kepada BS. Kaedah DMA menapis maklumat CH dengan menghantar maklumat baru kepada BS; oleh itu, kaedah ini membantu mengurangkan beban di BS. Prestasi model EULR dinilai melalui simulasi dengan dataset masa nyata. Secara keseluruhannya, model EULR mengurangkan bilangan CHs sebanyak 9.53%, peningkatan kestabilan CH sebanyak 40.38%, pengurangan paket yang hilang sebanyak 26.81% dan mengurangkan maklumat pendua di persimpangan sebanyak 81% berbanding hasil

kerja penyelidikan berkaitan sebelumnya. Akhirnya, kaedah yang dicadangkan telah menunjukkan hasil prestasi rangkaian yang signifikan seperti yang dinyatakan dalam tesis ini.

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LIST OF SYMBOLS

$\Delta D_{CH,CM}$	-	Relative distance between CH and CM
$\Delta D_{i,j}$	-	Difference in distance between vehicle i and vehicle j
$\Delta D_{N,I}$	-	Relative distance between NCH and ICH
$\Delta D_{O,I}$	-	Relative distance between OCH and ICH
$\Delta D_{O,N}$	-	Relative distance between OCH and NCH
$\Delta S_{CH,CM}$	-	The relative speed between CH and CM
$\Delta S_{i,j}$	-	Difference in speed between vehicle i and vehicle j
$\Delta S_{N,I}$	-	Relative speed between NCH and ICH
$\Delta S_{O,I}$	-	Relative speed between OCH and ICH
$\Delta S_{O,N}$	-	Relative speed between OCH and NCH
ARTD	-	Average Relative Distance
$ARTD_{PCH}$	-	Average Relative Distance to Primary Cluster-Heads
ARTS	-	Average Relative Speed
$ARTS_{MPCH}$	-	Average different speed to Main Primary Cluster-Heads
CH	-	Cluster Head
CH_F	-	Final Cluster Head
CM	-	Cluster Member
CONN	-	Number of connection to CH
d	-	Distance between two vehicles
DCHs	-	Difference in speed between OCH and NCH
DD_{thr}	-	Dynamic Distance Threshold
DS_{thr}	-	Dynamic Speed Threshold

D_{thrN}	-	Dynamic threshold speed of NCH
D_{thrO}	-	Dynamic threshold speed of OCH
INCONN	-	Number of interconnect to the CH
$LLT_{CH,CM}$	-	Link lifetime between CH and its CM
$LLT_{N,I}$	-	Link lifetime between NCH and ICH
$LLT_{O,I}$	-	Link lifetime between OCH and ICH
$LLT_{O,N}$	-	Link lifetime between OCH and NCH
MPCH	-	Main Primary Cluster-Heads
M_{PCH}	-	Number of Main Primary Cluster-Heads
N	-	total number of vehicles
N.O.V	-	Number of vehicles
NCH	-	New Cluster Head
NL	-	Number of road lanes
N_{PCH}	-	Number of Primary Cluster-Heads
OCH	-	Original Cluster Head
PCH	-	Primary Cluster-Heads
P_{CH}	-	Position of Cluster Head
P_{CM}	-	Position of Cluster member
P_i	-	Position of vehicle *i*
P_I	-	Position of ICH
P_j	-	Position of vehicle *j*
P_N	-	Position of NCH
P_O	-	Speed of OCH
P_{PCH}	-	Position of Primary Cluster-Heads
RTD	-	Relative Distance
RTS	-	Relative Speed
S_{CH}	-	Speed of CH

S_{CM}	-	Speed of CM
S_i	-	Speed of vehicle *i*
S_I	-	Speed of ICH
S_j	-	Speed of vehicle *j*
S_{MPCH}	-	Speed of Main Primary Cluster-Heads
S_N	-	Speed of NCH
S_O	-	Speed of OCH
TR	-	Vehicle transmission range
TR_{CH}	-	Transmission range of CH
TR_I	-	Transmission range of ICH
TR_O	-	Transmission range of OCH
VL	-	Vehicle length
VS	-	Vehicle speed

LIST OF ABBREVIATIONS

AATR	-	Adaptive Allocation Of Transmission Range
ACH	-	Agent-Cluster-Head
ACO	-	Ant Colony Optimization Algorithm
ADCHV	-	Agent Based Dynamic Clustering For Hybrid VANET
AgB	-	Agent-Beacon
AKHM	-	Adaptive K-Harmonic Means Clustering Algorithm
ALM	-	Aggregate Local Mobility
AMACAD	-	Adaptable Mobility-Aware Clustering Algorithm Based On Destination Positions
ANTSC	-	Intelligent Naïve Bayesian Probabilistic Estimation Practice For Traffic Follow To Form A Stable Clustering
AP	-	Affinity Propagation
ARTD	-	Average Relative Distance
ARTS	-	Average Relative Speed
ASVA NET	-	Ant System-Based Clustering Algorithm
AWCP	-	Adaptive Weighted Clustering Protocol
BCS	-	Backoff-Based Cluster Head Selection
BS	-	Base-Station
BSCH	-	Base-Station-Cluster-Head
BUCH	-	Backup Cluster Head Based Cluster Maintenance Approach
BUCH	-	Backup Cluster Head Based Cluster Maintenance Scheme
CACONET	-	Clustering Algorithm Based On Ant Colony Optimization (ACO) For Vanets
CAMONET	-	Clustering Algorithm Centered On Moth-Flame Optimization For Vanets
CBL	-	Chain-Branch-Leaf

CBLS	-	Cluster Based Location Service
CBLTR	-	Cluster-Based Life-Time Routing Protocol
CCH	-	Control Channel
CC-HVNA	-	Centralized Clustering Based Hybrid Vehicular Networking Architecture
CH	-	Cluster-Head
CHE	-	Cluster Head Election
CHt	-	Temporary Cluster Head
CLPSO	-	Comprehensive Learning Particle Swarm Optimization
CM	-	Cluster-Member
CMS	-	Cluster Management System
CODE	-	Cluster-Based On-Demand Delay Tolerant Routing Algorithm
CORA	-	Control Overhead Reduction Algorithm
CSIM19	-	Converged Security Information Management
DA-CMAC	-	Direction Based Clustering And Multi-Channel Medium Access Control
DBC	-	Density Based Clustering Algorithm
DCA	-	Dynamic Clustering Algorithm
DCA	-	Direction-Based Clustering Algorithm
DDthr	-	Dynamic Distance Threshold
DHCV	-	D-Hop Clustering Algorithm
DIAC	-	Destination- And Interest-Aware Clustering Mechanism
DMA	-	Dynamic Multi-Agent
DMA	-	Dynamic Multi-Agent
DMCNF	-	Distributed Multi-Hop Clustering Algorithm For Vanets Based On Neighborhood Follow
DMCS	-	Dynamic Mobility-Based Clustering Scheme
DMMAC	-	Distributed Multichannel And Mobility Aware Cluster-Based MAC Protocol
DSthr	-	Dynamic Speed Threshold
Dt	-	Safe Distance Threshold
EDP	-	Efficient Data Dissemination Protocol

EGT	-	Evolutionary Game Theoretic Framework
EnLOSC	-	Enhanced Low Overhead And Stable Clustering Scheme
ETM	-	End Time Message
FIS	-	Fuzzy-Logic Inference System
SCHE	-	Smart Cluster-Head Election
GMM	-	Gauss Markov Mobility
GNSS	-	Global Navigation Satellite System
GPS	-	Global Positioning System
GTLQR	-	Greedy Traffic Light And Queue Aware Routing Protocol
GVC	-	General-Purpose VANET Clustering Scheme
GW	-	Gateway
GWOCNETs	-	Grey Wolf Optimization Based Clustering Algorithm For Vanets
HCA	-	Hierarchical Clustering Algorithm
HCBLS	-	Hierarchical Cluster-Based Location Service In City Environments
HCHE	-	Hybrid Cluster-Head Election
ICH	-	Intelligent Cluster-Head
IDS	-	Lightweight Anomaly Based
IDVR	-	Intersection Dynamic VANET Routing Protocol
INCH	-	Inter-Cluster-Head State
INT-SMS	-	Intersection-Message
iTETRIS	-	Integrated Wireless And Traffic Platform For Real-Time Road Traffic Management Solutions
ITS	-	Intelligent Transportation Systems
IWD	-	Intelligent Water Drop Algorithm
IWD-QoS-OLSR	-	Quality Of Service Optimized Link State Routing Based On The Intelligent Water Drop Algorithm
JADE	-	Java Agent Development Frame Word
LA	-	Learning Automata
LENA	-	Language Environment Analysis System
LIGO	-	Laser Interferometer Gravitational-Wave Observatory
LLT	-	Link Lifetime

LOSC	-	Ligo Open Science Center
LRCA	-	Link Reliability-Based Clustering Algorithm
LTE	-	Long Term Evolution Lte
MANETs	-	Mobile Ad Hoc Networks
MATLAB	-	Matrix Laboratory Software
MC	-	Mobile Cloud
MES	-	Broadcast Message
MFO	-	Moth-Flame Optimization
MMZ	-	Multi-Hop Moving Zone
MobiSim	-	Mobility Simulation
MOPSO	-	Multi-Objective Particle Swarm Optimization
MOVE	-	Mobility Model Generator For Vehicular Networks Software
MPCH	-	Main Primary Cluster-Head
MSCA	-	Mobility-Based And Stability-Based Clustering Algorithm
N.O.CH	-	Number Of Cluster-Head
NCABAT	-	Novel Clustering Algorithm Based On Agent Technology Denoted
NCH	-	New Cluster-Head
NS	-	Network Simulator Software
NS	-	Neighbor Sampling
NSVC	-	Neighbor Stability-Based VANET Clustering
OBUs	-	On-Board Units
OCH	-	Original Cluster-Head
Omnet++	-	Objective Modular Network Testbed In C++
OSM	-	Open Street Map Software
PCH	-	Primary Cluster-Head
PDR	-	Packet Delivery Ratio
PMC	-	Passive Multi-Hop Clustering Algorithm
PSO	-	Particle Swarm Optimization
QoS-OLSR	-	Quality Of Service Optimized Link State Routing Protocol
QoS-OLSR	-	Quality Of Service Optimized Link State Routing
ReSCUE	-	Relatively Stable Clustering For Unbiased Environments

RPC	-	Roadside Parking Cloud
RSS	-	Receiving Signal Strength
RSUs	-	Roadside Units
RTD	-	Relative Distance
RTS	-	Relative Speed
RTVC	-	Real Time Vehicular Communication
SBCA	-	Stability-Based Clustering Algorithm
SCalE	-	Stable Clustering Algorithm For Vehicular Ad Hoc Networks
SCH	-	Service Channels
SDN	-	Software-Defined Networking
SESAC	-	Software-Defined Networking (SDN)-Enabled Social-Aware Clustering Algorithm
SGTA	-	Strategic Game-Theoretic Algorithm
SLCA	-	Self-Location Calculation Algorithm
SUMO	-	Simulation Of Urban Mobility Software
TCRP	-	Triple Cluster Based Routing Protocol
TR	-	Transmission Range
TR	-	Transmission Range
UFC	-	Unified Framework Of Clustering Approach
UMTS	-	Universal Mobile Telecommunication Systems
UN	-	Undecided State
V2I	-	Vehicle-To-Infrastructure
V2V	-	Vehicle-To-Vehicle
Vanetmobisim	-	Vehicular Adhoc Networks Mobility Simulator
VANETs	-	Vehicular Ad Hoc Networks
VC	-	Vehicular Cloud
VCS	-	VANET Cluster Scheme
VH	-	Vehicle Head
VMaSC	-	Vehicular Multi-Hop Algorithm For Stable Clustering
VMaSC-LTE	-	Vehicular Multi-Hop Algorithm For Stable Clustering With Long Term Evolution
VMR	-	VANET-Multi-Cast Routing

VPCs	-	Passive Clustering (PC)-Based Techniques
VWCA	-	Vehicular Clustering Based On The Weighted Clustering Algorithm
WoS	-	Web Of Science
WSM	-	Weak Signal Message
WSNs	-	Wireless Sensor Networks

LIST OF APPENDICES

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